TECH 646 Analysis of Research in Industry and Technology

PART IV

Ch. 17 Hypothesis Testing (2 of 2)

Lecture note based on the text book and supplemental materials:

1. **Cooper, D.R., & Schindler, P.S., *Business Research Methods* (12th edition), McGraw-Hill/Irwin**
2. **D. C. Montgomery and G. C. Runger, Applied Statistics and Probability for Engineers, 6th Ed, Wiley**

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A Core Course for M.S. iln Technology Program

Purdue University Fort Wayne

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Tests of Significance

(Two general classes)

- Parametric Tests
  - More powerful
  - Data from Interval to Ratio Scale
- NonParametric Tests
  - Used to test hypotheses with data of Nominal and Ordinal Scale

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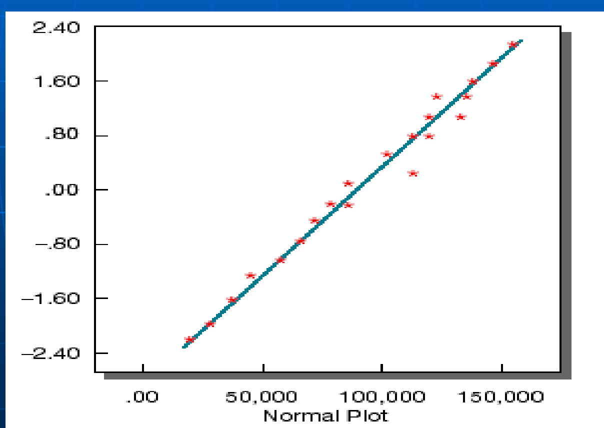
Assumptions for Using Parametric Tests

1. **Independent observations**
2. **Normal distribution**
3. **Equal variances**
4. **Interval or ratio scales**

Probability Plots and Test of Normality

- Normal probability plot compares with a normal distribution
- The points fall within a narrow band along a straight line



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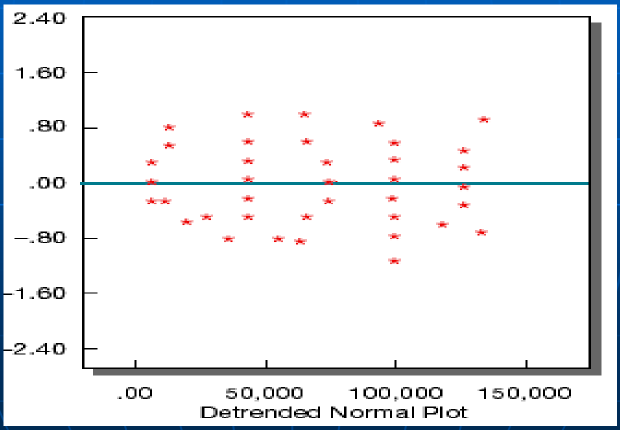
Probability Plots and Test of Normality

- Detrented plot - the deviation from the straight line
- Expect the points to cluster without pattern around a straight line passing horizontally through 0.



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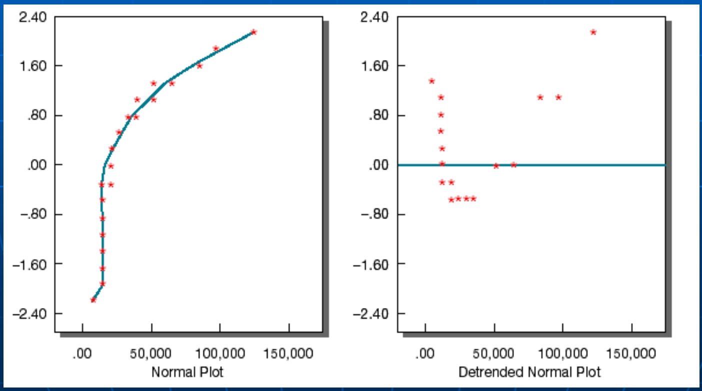
Probability Plots and Test of Normality

- **The variable is not normally distributed**



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Advantages of Nonparametric Tests

- Easy to understand and use
- Usable with nominal data
- Appropriate for ordinal data
- Appropriate for non-normal population distributions

How to Select a Test

- How many samples are involved?
- If two or more samples, are involved, are the individual cases independent or related?
- Is the measurement scale nominal, ordinal, interval, or ratio?
- See Recommended Statistical Techniques next

Recommended Statistical Techniques by Measurement Level and Testing Situation

		Two-Sample Tests		k-Sample Tests	
Measurement Scale	*One-Sample Case*	*Related Samples*	*Independent Samples*	*Related Samples*	*Independent Samples*
Nominal	• *Binomial* • x^2 *one-sample test*	• *McNemar*	• *Fisher exact test* • x^2 *two-samples test*	• *Cochran Q*	• x^2 for k *samples*
Ordinal	• *Kolmogorov-Smirnov one-sample test* • *Runs test*	• *Sign test* • *Wilcoxon matched-pairs test*	• *Median test* • *Mann-Whitney U* • *Kolmogorov-Smirnov* • *Wald-Wolfowitz*	• *Friedman two-way ANOVA*	• *Median extension* • *Kruskal-Wallis one-way ANOVA*
Interval and Ratio	• t-*test* • *Z test*	• t-*test for paired samples*	• t-*test* • *Z test*	• *Repeated-measures ANOVA*	• *One-way ANOVA* • n-*way ANOVA*

Questions Answered by One-Sample Tests

- Is there a difference between **observed frequencies** and the frequencies we would expect?
- Is there a difference between observed and expected **proportions**?
- Is there a significant difference between some measures of **central tendency** and the population parameter?

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One-Sample: parametric Tests

- Determine the statistical significance between a sample distribution mean and a parameter
- Z Test

$$Z_0 = \frac{\bar{X} - \mu_0}{\sigma / \sqrt{n}}$$

- t-Test

$$T = \frac{\bar{X} - \mu_0}{S / \sqrt{n}}$$

- When sample size n > 120, Z test and t-test are identical

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One-Sample Parametric Tests

- **Real-world Application Examples**
  - Finding the average monthly balance of credit card holders compared to the average monthly balance five years ago.
  - Comparing the failure rate of computers in a 20 hours test of quality specifications
  - Discovering the proportion of people who would shop in a new district compared to the assumed population proportion.
  - Comparing the average product revenues this year to last year's revenue

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One-Sample t-Test Example

- **The hybrid-vehicle problem**
- A sample of 100 vehicles
- Find the mean miles per gallon for the car is 52.5 mpg, with a standard deviation of 14
- Does these results indicate that population mean might still be 50?
  1. Null Hypothesis
     - H0 := 50 mpg
     - HA: > 50 mpg (one-tailed test)
  2. Statistical Test
     - t-Test is selected because the data are ratio measurement

$$T = \frac{\bar{X}-\mu_0}{s/\sqrt{n}}$$

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One-Sample t-Test Example

- Does these results indicate that population mean might still be 50?
  1. Null Hypothesis
     - H0 := 50 mpg
     - HA: > 50 mpg (one-tailed test)
  2. Statistical Test
     - t-Test is selected because the data are ratio measurement
  3. Significance level
     - $\alpha = 0.05,\ n = 100$
  4. Calculated value

$$T = \frac{\bar{X}-\mu_0}{s/\sqrt{n}} = \frac{52.5-50}{14/\sqrt{100}} = \frac{2.5}{1.4} = 1.786,\quad d.f = n-1 = 99$$

  5. Critical test value (Appendix D, Exhibit D-2, page 621)
     - Interpolated between d.f = 60 and d.f. = 120, A level of significance 0.05
     - Critical value of t = 1.66
  6. Interpretation

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One-Sample t-Test Example

- Does these results indicate that population mean might still be 50?
  6. Interpretation
     - The calculated value 1.786 > the critical value 1.66
     - Reject the null hypothesis
     - Conclude that the average mpg has increased

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One-Sample *t*-Test Example - Summary

Null	*Ho: = 50 mpg*
Statistical test	*t-test*
Significance level	*0.05, n=100*
Calculated value	*1.786*
Critical test value	*1.66 (from Appendix D, Exhibit D-2)*

One-Sample Chi-Square-Test Example

- A **survey of student interest** in **Metro University Dinning Club**.
- **200 students** were interviewed about their interest in joining the club.
- The results are **classified by living arrangement**.
- Is there a **significant difference** among these students?

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One Sample Chi-Square Test Example - Summary

Null	*Ho: 0 = E*
Statistical test	*One-sample chi-square*
Significance level	*.05*
Calculated value	*9.89*
Critical test value	*7.82*

Chi-Square-Test Formula

- The Ch-Square test formula

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

O_i = observed number of cases categorized in the i^{th} category

E_i = expected number of cases in the i^{th} category under H0

K = number of categories

d.f = k – 1

d.F = (r-1)(c-1); r – row, c - column

$$\chi^2 = \frac{(16-27)^2}{27} + \frac{(13-12)^2}{12} + \frac{(16-12)^2}{12} + \frac{(15-9)^2}{9} = 4.48 + 0.08 + 1.33 + 4.0 = 9.89$$

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Ch-SquareTest Example

- Is there a significant difference among these students?
  1. Null Hypothesis
     - H0 :Oi = Ei (The proportion in the population who intend to join the club is independent of living arrangement)
     - HA: Oi ≠ Ei
  2. Statistical Test
     - One sample Chi-square Test is selected because the response are classified into Nominal categories and there are sufficient observations
  3. Significance level
     - $\alpha = 0.05$
  4. Calculated value

$$\chi^2 = \frac{(16-27)^2}{27} + \frac{(13-12)^2}{12} + \frac{(16-12)^2}{12} + \frac{(15-9)^2}{9} = 4.48 + 0.08 + 1.33 + 4.0 = 9.89$$

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One Sample Chi-Square Test Example (Nominal data)

Living Arrangement	Intend to Join	Number Interviewed	Percent (no. interviewed/200)	Expected Frequencies (percent x 60)
Dorm/fraternity	16	90	45	27
Apartment/rooming house, nearby	13	40	20	12
Apartment/rooming house, distant	16	40	20	12
Live at home	15	30	15	9
Total	60	200	100	60

Chi-Square-Test

4. Calculated value: the Ch-Square test formula

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

O_i = observed number of cases categorized in the i^{th} category

E_i = expected number of cases in the i^{th} category under H0

K = number of categories

d.f = k – 1

d.f = (r-1)(c-1) = (4-1)(2-1) = 3

$$\chi^2 = \frac{(16-27)^2}{27} + \frac{(13-12)^2}{12} + \frac{(16-12)^2}{12} + \frac{(15-9)^2}{9} = 4.48 + 0.08 + 1.33 + 4.0 = 9.89$$

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Ch-SquareTest Example

- Is there a significant difference among these students?
  5. Critical test value (Appendix D, Exhibit D-3, page 622)
     - d.f = 3
     - $\alpha = 0.05$
     - Critical value of 7.82
  6. Interpretation
     - The calculated value (9.89) is greater than the Critical value (7.82)
     - The null hypothesis is rejected.
     - We conclude that intending to join is **dependent on living arrangement**

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One Sample Chi-Square Test Example

Living Arrangement	*Intend to Join*	*Number Interviewed*	*Percent (no. interviewed/200)*	*Expected Frequencies (percent x 60)*
Dorm/fraternity	*16*	*90*	*45*	*27*
Apartment/rooming house, nearby	*13*	*40*	*20*	*12*
Apartment/rooming house, distant	*16*	*40*	*20*	*12*
Live at home	*15*	*30*	*15*	*9*
Total	*60*	*200*	*100*	*60*

Two-Sample Parametric Tests

$$Z = \frac{(\overline{X_1} - \overline{X_2}) - (\mu_1 - \mu_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

$$t = \frac{(\overline{X_1} - \overline{X_2}) - (\mu_1 - \mu_2)}{\sqrt{S_p^2(\frac{1}{n_1} + \frac{1}{n_2})}}$$

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Two-Sample t-Test Example

	A Group	*B Group*
Average hourly sales	X_1 = *$1,500*	X_2 = *$1,300*
Standard deviation	s_1 = *225*	s_2 = *251*

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Two-Independent-Samples Tests Example

- Is there a significant difference among the group A and B?
  1. Null Hypothesis
     - H0 : There is no difference in sales results produced by two training methods
     - HA: Training method A produces sales results superior to those of method B
  2. Statistical Test
     - T-test: data are at least Interval, and the samples are independent
  3. Significance level
     - $\alpha = 0.05$ (one-tail test)
  4. The Calculated value

$t = 1.97, \quad d.f = (11-1) + (11-1) = 20$

  5. Critical test value (Appendix D, Exhibit D-2, page 621)
     - Interpolated between d.f = 20, level of significance 0.05
     - Critical value of t = 1.725
  6. Interpretation
     - Since the calculated value is larger than the critical value (1.97 > 1.725), reject the null hypothesis and concluded that training method A is superior.

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Two-Sample t-Test Example - summary

Null	*Ho: A sales = B sales*
Statistical test	*t-test*
Significance level	*0.05 (one-tailed)*
Calculated value	*1.97, d.f. = 20 = (11-1)+(11-1)*
Critical test value	*1.725 (Appendix D, Exhibit D-2)*

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SPSS Cross-Tab Procedure

- Yate's correction for continuity is applied for
  - Sample size n > 40, or
  - Sample is between 20 and 40 and the value of Ei are 5 or more
- The χ^2 of 2 x 2 table

A	**B**
C	**D**

- The formula for Yete' correction

$$\chi^2 = \frac{n(|AD - BC| - \frac{n}{2})^2}{(A+B)(C+D)(A+C)(B+D}$$

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Exhibit 17-8 SPSS Cross-Tab Procedure (Income by Possession of MBA)

- Chi-square = 6.25, without the correction; with an observed level of significance of 0.01242
- Chi-square (with Yate's correction) = 5.25; significance level = 0.02192
  - If α = 0.01; we would accept the null since 0.02192 > 0.01
- The literature is in conflict over the merits of Yates' correction
- Mantel-Haenszel test (used with Ordinal data)
- Likelihood ratio test (produce results similar to Pearson's Ch-square)

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Exhibit 17-8 SPSS Cross-Tab Procedure (Income by Possession of MBA)

INCOME BY POSSESSION OF MBA

INCOME	Count	MBA Yes 1	No 2	Row Total
	High 1	30	30	60 60.0
	Low 2	10	30	40 40.0
	Column Total	40 40.0	60 60.0	100 100.0

Chi-Square	Value	D.F.	Significance
Pearson	6.25000	1	.01242
Continuity Correction	5.25174	1	.02192
Likelihood Ratio	6.43786	1	.01117
Mantel-Haenszel	6.18750	1	.01287

Minimum Expected Frequency: 16.000

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Two-Related Sample Tests

- Concern those situations in which persons, objects, or events are closely matched or the phenomena are measured twice.
- Parametric Test
  - T-test for independent samples is in appropriate here because of its assumption that observations are independent
- Non-Parametric Test
  - The McNemar test may be used (nominal or ordinal data)
  - Especially useful with before-after measurement of the same subjects.

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Parametric Test

- Parametric Test
  - T-test for independent samples is in appropriate here because of its assumption that observations are independent
  - The problem is solved by a formula in which the difference is found between each matched pair of observations.

$$t = \frac{\bar{D}}{S_D/\sqrt{n}} \qquad \bar{D} = \frac{\sum D}{n} S_D = \sqrt{\frac{\sum D - \frac{(\sum D)^2}{n}}{n-1}}$$

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Exhibit 17-9 Sales Data for Pair-Samples t-Test (dollars in millions)

Company	**Sales *Year 2***	**Sales *Year 1***	***Difference D***	***D*²**
GM	12693	123505	3427	11744329
GE	54574	49662	4912	24127744
Exxon	54574	78944	7712	59474944
IBM	86656	59512	3192	10227204
Ford	62710	92300	3846	14971716
AT&T	96146	35173	939	881721
Mobil	36112	48111	2109	4447881
DuPont	50220	32427	2632	6927424
Sears	35099	49975	3819	14584761
Amoco	53794	20779	3187	10156969
Total	23966		ΣD = 35781 .	ΣD = 157364693 .

Pair-Samples t-Test

- Two years of Forbes sales data from 10 companies
- Null hypothesis
  - H0: $\mu = 0$; there is no difference between year 1 and year 2 sales.
  - HA: $\mu \neq 0$; there is a difference between year 1 and year 2 sales.
- Statistical test:
  - The matched- or paired-samples t-test; measurement is ratio data
- Significance level
  - $\alpha = 0.01$, with n = 10 and d.f. = n-1
- Calculated value
- Critical test value
- Interpretation

Pair-Samples t-Test

- Calculated value: t = 6.27; d.f. = 9
- Critical test value: (Appendix D, Exhibit D-2, with d.f. = 9; two-tailed test, $\alpha = 0.01$. The critical value is 3.25.
- Interpretation
  - The calculated value (6.27) > the critical value (3.25)
  - Reject the null hypothesis
  - Conclude there is **a statistical significant difference between the two years sales**

Paired-Samples t-Test

Null	Year 1 sales = Year 2 sales
Statistical test	Paired sample t-test
Significance level	0.01
Calculated value	6.28, d.f. = 9
Critical test value	3.25 (from Appendix D, Exhibit D-2)

Exhibit 17-10 SPSS Output for 10 Companies Paired-Samples t-Test

- The SPSS output rounded 0.0005 to 0.000

---t-tests for paired samples---

Variable	Number of Cases	Mean	Standard Deviation	Standard Error
Year 2 Sales	10	62620.9	31777.649	10048.975
Year 1 Sales	10	59038.8	31072.871	9836.104

(Difference Mean)	Standard Deviation	Standard Error	Corr.	2-tail Prob.	*t* Value	Degrees of Freedom	2-tail Prob.
3582.1000	1803.159	570.209	.999	.000	6.28	9	.000

SteelShelf Corp., New Concept Seating

- 200 employees were divided into equal groups reflecting their favorable or unfavorable view of the design using a questionnaire.
- After the campaign, the same 200 employees were asked again to complete the same questionnaire
- McNemar Test example (nominal or ordinal data)
- Test the significance of any observed change (before/after)

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SteelShelf Corp.,New Concept Seating

- McNemar Test example (nominal or ordinal data)
- Test the significance of any observed change (before/after)
- A + D => total number of people changes
- B + C => total no-change response

Before	After Do Not Favor	After Favor
Favor	A	B
Do Not Favor	C	D

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SteelShelf Corp.,New Concept Seating

- McNemar Test example (nominal or ordinal data)

Before	After Do Not Favor	After Favor
Favor	A=10	B=90
Do Not Favor	C=60	D=40

SteelShelf Corp.,New Concept Seating
The Hypothesis Testing Process

- Null hypothesis
  - H0: P(A) = P(D); new concept seating has no effect on employees' attitudes
  - HA: P(A) ≠ P(D); new concept seating had effect on employees' attitudes
- Statistical test:
  - The McNemar test; nominal data, before/after measurement of two related samples
- Significance level
  - $\alpha = 0.05$, n = 200
- Calculated value: $\chi^2 = 16.82$, d.f. = 1 (page 453)

$\chi^2 = (|A - D| - 1)^2/(A + D)$ with d.f. = 1

$= (|10 - 40| - 1)^2/(10 + 40) = 29^2/50 = 16.82$

SteelShelf Corp.,New Concept Seating The Hypothesis Testing Process

- Critical test value
  - Use Appendix D, Exhibit D-3
  - α = 0.05, d.f. = 1 => find the critical value = 3.84
- Interpretation
  - The calculated value (16.82) > the critical value (3.83)
  - Reject null hypothesis
  - Conclude that the **new concept had a significant positive effect on employees' attitudes**.

K-Independent-Sample Tests: ANOVA

- **Tests the null hypothesis that the means of three or more populations are equal**
- **One-way**: Uses a single-factor, fixed-effects model to compare the effects of a treatment or factor on a continuous dependent variable
- ANOVA (Analysis of Variance)
- To use ANOVA, certain conditions must be met.
  - The **samples must be randomly** selected from normal populations and the populations should have equal variances.
  - The distance from one value to its group's mean should be independent of the distances of other values to that mean.

K-Independent-Sample Tests: ANOVA

- In an ANOVA
  - **Each group** has its own mean and values that deviate from that mean.
  - The **total deviation** is the sum of the squared differences between each data point and the overall grand mean.
- Example: Airline Flight Service Rating
  - All data are hypothetical
  - Three airlines: 1 = Lufthansa; 2 = Malaysia Airlines; 3 = Cathay Pacific
  - Seat selection: 1 = economy; 2 = business
  - 20 passengers were randomly selected for each airlines (total of 60 passengers)
  - Concerns only the two columns: "Fight Service Rating 1" and Airline
  - The factor, airline, is the grouping variable for three carriers

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K-Independent-Sample Tests: ANOVA

- The test statistics for ANOVA is F ratio
- F = between-groups variance/within-groups variance

  = Mean square $_{\text{between}}$/Mean square $_{\text{within}}$

where

Mean square $_{\text{between}}$ = SumOfSquares $_{\text{between}}$/d.f. $_{\text{between}}$

Mean square $_{\text{within}}$ = SumOfSquares $_{\text{within}}$/d.f. $_{\text{within}}$

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3-Airline Service Rating Testing Procedure

- Null hypothesis
  - H0 : μA1 = μA2 = μA3
  - HA: μA1 ≠ μA2 ≠ μA3 (The means are not the same)
- Statistical test
  - The F test is chosen
  - K independent samples, Interval data
  - Accept the assumptions of ANOVA
- Significance level
  - α = 0.05, d.f. =[numerator (k-1) = (3-1) = 2] ,
  - [denominator (n-k) = (60-3) = 57] = (2, 57)
- Calculated value
  - F = MSb/MSw = 5822.017/205.695 = 28.304

Exhibit 17-12 Three-Airlines: ANOVA Example

Model Summary

Source	d.f.	Sum of Squares	Mean Square	*F* Value	*p* Value
Model (airline)	2	11644.033	5822.017	28.304	0.0001
Residual (error)	57	11724.550	205.694		
Total	59	23368.583			

Means Table

	Count	Mean	Std. Dev.	Std. Error
Lufthansa	20	38.950	14.006	3.132
Malaysia Airlines	20	58.900	15.089	3.374
Cathay Pacific	20	72.900	13.902	3.108

All data are hypothetical

3-Airline Service Rating Testing Procedure

- Critical test value
  - Use Exhibit D-8 (pp. 626), with d.f. = (2, 57)
  - Critical test value = 3.16
- Interpretation
  - Calculated value (28.304) > Critical value (3.16)
  - Reject the null hypothesis
  - P value = 0.0001 < alpha (0.05) => a second method to reject Null
  - Conclude that there is a significant difference in flight service ratings

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Scheffe's S Multiple Comparison (Range Test) Procedure

- With an ANOVA, we cannot tell which pairs are not equal. We can use a post hoc test to determine where the differences lie.
- pp. 454-456

	Verses	Diff	Crit. Diff.	p Value
Lufthansa	Malaysia Airlines	19,950	11.400	.0002
	Cathay Pacific	33.950	11.400	.0001
Malaysia Airlines	Cathay Pacific	14.000	11.400	.0122

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Multiple Comparison Procedures

	Complex Comparisons	Pairwise Comparisons	Equal *n*'s Only	Unequal *n*'s	Equal Variances Assumed	Unequal Variances Not Assumed
Fisher LSD	X			X	X	
Bonferroni	X		X	X		
Tukey HSD	X		X		X	
Tukey-Kramer	X			X	X	
Games-Howell	X			X		X
Tamhane T2	X			X		X
Scheffé S		X	X	X	X	
Brown-Forsythe		X	X	X		X
Newman-Keuls	X				X	
Duncan	X				X	
Dunnet's T3						X
Dunnet's C						X

Multiple Comparison Procedures

- Fisher LSD (Least Significant Difference), http://support.minitab.com/en-us/minitab/17/topic-library/modeling-statistics/anova/multiple-comparisons/what-is-fisher-s-lsd-method/
- Bonferroni, http://www.itl.nist.gov/div898/handbook//prc/section4/prc473.htm
- Turkey HSD (Honest Significant Test), https://en.wikipedia.org/wiki/Tukey's_range_test
- Turkey-Krammer (work with uneqal sample sizes), http://www.itl.nist.gov/div898/handbook/prc/section4/prc471.htm
- Games-Howell
- Tamhane T2
- Scheffe S
- Brown-Forsythe
- Newman-Keuls

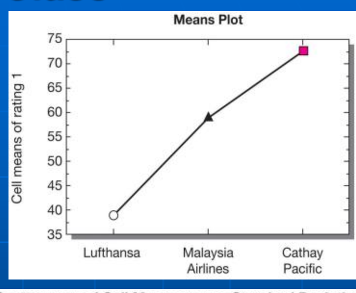
Multiple Comparison Procedures

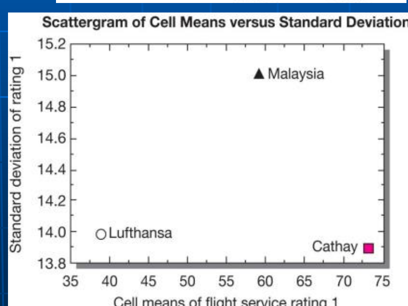
IBM SPSS Knowledge Center, http://www.ibm.com/support/knowledgecenter/SSLVMB_21.0.0/com.ibm.spss.statistics.help/idh_onew_post.htm

- Tamhane T2,
- Scheffe S
- Brown-Forsythe
- Newman-Keuls
- Duncan, https://en.wikipedia.org/wiki/Duncan's_new_multiple_range_test
- Dunnel;s T3

Exhibit 17-14 ANOVA Plots (One-way): Business Class

- Mean plot – shows relative difference among the three levels of the factor
- Mean vs. Standard Deviation plot – reveals variability in the opinion recorded





Example 17-15 Two-Way ANOVA Example (Adding Seat Selection: Economy, Business)

- We can now answer three questions:
  - Are differences in flight service ratings attributable to airlines?
  - Are differences in flight service ratings attributable to seat selection?
  - Do the airline and seat selections interact with respect to flight service ratings?
- Exhibit 17-15 reports a test of the hypotheses for these 3 questions

Model Summary					
Source	d.f.	Sum of Squares	Mean Square	*F* Value	*p* Value
Airline	2	11644.033	5822.017	39.178	0.0001
Seat selection	1	3182.817	3182.817	21.418	0.0001
Airline by seat selection	2	517.033	258.517	1.740	0.1853
Residual	54	8024.700	148.606		

Example 17-15 Two-Way ANOVA Example (Adding Seat Selection: Economy, Business)

	Means Table Effect: Airline by Seat Selection			
	Count	Mean	Std. Dev.	Std. Error
Lufthansa economy	10	35.600	12.140	3.839
Lufthansa business	10	42.300	15.550	4.917
Malaysia Airlines economy	10	48.500	12.501	3.953
Malaysia Airlines business	10	69.300	9.166	2.898
Cathay Pacific economy	10	64.800	13.037	4.123
Cathay Pacific business	10	81.000	9.603	3.037

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K-Related Samples Test

- More than two levels in grouping factor
- Observations are matched
- Data are interval or ratio

Exhibit 17-17:

- Null hypotheses:
- (1) Airline H0: $\mu_{A1} = \mu_{A2} = \mu_{A3}$
- (2) Ratings H0: $\mu_{R1} = \mu_{R2}$
- (3) Rating x Airline: H0:
  - $(\mu_{R2A1} - \mu_{R2A2} - \mu_{R2A3}) = (\mu_{R1A1} - \mu_{R1A2} - \mu_{R1A3})$

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Example 17-17 Repeated-Measures ANOVA Example

Model Summary

Source	d.f.	Sum of Squares	Mean Square	*F* Value	*p* Value
Airline	2	3552735.50	17763.775	67.199	0.0001
Subject (group)	57	15067.650	264.345		
Ratings	1	625.633	625.633	14.318	0.0004
Ratings by air.......	2	2061.717	1030.858	23.592	0.0001
Ratings by subj.....	57	2490.650	43.696		

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Example 17-17 Repeated-Measures ANOVA Example

Means Table by Airline				
	Count	Mean	Std. Dev.	Std. Error
Rating 1, Lufthansa	20	38.950	14.006	3.132
Rating 1, Malaysia Airlines	20	58.900	15.089	3.374
Rating 1, Cathay Pacific	20	72.900	13.902	3.108
Rating 2, Lufthansa	20	32.400	8.268	1.849
Rating 2, Malaysia Airlines	20	72.250	10.572	2.364
Rating 2, Cathay Pacific	20	79.800	11.265	2.519

Example 17-17 Repeated-Measures ANOVA Example

Means Table Effect: Ratings				
	Count	Mean	Std. Dev.	Std. Error
Rating 1	60	56.917	19.902	2.569
Rating 2	60	61.483	23.208	2.996

Summary

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